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A CONTRIBUTION TO THE
PATHOLOGY OF THE CORON-
ARY ARTERIES OF THE HEART,
BY JOHN LINDSAY STEVEN,
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A CONTRIBUTION TO THE PATHOLOGY OF THE CORONARY ARTERIES OF THE HEART,

BASED UPON AN ANALYSIS OF 238 CASES IN WHICH THE CONDITION OF THESE ARTERIES WAS ASCERTAINED AFTER DEATH; WITH OBSERVATIONS UPON THE RELATIONSHIP OF DISEASE OF THESE VESSELS TO SUDDEN DEATH AND ANGINA PECTORIS.

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In this paper I propose to give a short analysis of the notes I have preserved of 238 cases in which the coronary arteries of the heart were carefully examined by splitting them up to their terminal branches, and the appearances observed recorded. During the six years that I acted as Pathologist to the Glasgow Royal Infirmary it was my routine practice to examine these arteries, although the result of such examination was not always noted, but in the present paper I shall deal only with those cases concerning which definite statements as to the condition of the coronary arteries have been entered in the report.

Of the 238 cases here dealt with, the coronary arteries were found to be healthy in 136, and diseased, *i.e.* atheromatous, or calcified, or occluded, in 102. No attempt will be made in this paper to tabulate the amount of disease in the coronary arteries, in all cases it was such as to be distinctly visible to the naked eye. The subdivision into healthy and diseased gives us a primary basis of classification.

I. CORONARY ARTERIES HEALTHY—136 CASES.

Of these cases obviously there is not a great deal to be said. It becomes at once clear that the only point of interest in

reference to them is to determine in how many of them the heart was otherwise healthy, and in those cases where the heart was diseased in other respects to state the character of the lesion. This may be best shown in a tabular form, as follows:

A. Heart noted to be healthy,	- - -	61 cases.
B. Heart noted to be diseased—		
(1) Hypertrophy and dilatation,	20 cases.	
(2) Aortic valve disease,	12 ,,	
(3) Mitral and aortic disease,	2 ,,	
(4) Simple hypertrophy of left ventricle,	19 ,,	
(5) Fatty infiltration of heart,	8 ,,	
(6) Fatty degeneration of heart,	1 ,,	
(7) Mitral disease,	6 ,,	
(8) Pulmonary stenosis,	1 ,,	
(9) Pericarditis,	2 ,,	
(10) Fibroid disease,	4 ,,	
	—	75 ,,
Total,	- - -	136 cases.

In this table I have included, for purposes of classification, merely the predominating lesion of the heart, and the only addition I wish to make to it is a statement of the number of cases in which fatty metamorphosis was also found to be present, as obviously this is a condition which is believed to have a special relationship to disease of the coronary arteries, and may exist along with other lesions. In the table are included 9 cases in which fatty change was the only lesion. In addition there fall to be added 4 cases in which fatty change complicated other lesions, making a total of 13 cases of fatty heart in which the coronary arteries were found to be healthy.

With regard to the condition of the aorta, I have also to add that of the 136 cases of healthy coronary arteries there were 17 in which the aorta was recorded to have been in a state of atheroma.

Cases of Cardiac Pain, or Angina Pectoris without Disease of the Coronary Arteries.

Among the cases of healthy coronary arteries there were at least four, concerning which the clinical summary recorded the presence of cardiac pain, probably of the nature of angina pectoris, as a notable symptom. A very brief summary of these four cases, in two of which the term angina pectoris is actually used in the clinical summary, may now be given.

(1) A wood-carver, aged 54, had been breathless for ten years. A week before his admission he felt severe pain in the chest, and for three days before it he had frequent attacks of angina pectoris. He only lived for three days after coming into hospital. In this case the coronary arteries were found to be quite healthy, but there was marked stenosis both of the mitral and the aortic orifices, and the muscular tissue of the left ventricle was beset with numerous fibrous scars, probably of embolic origin.

(2) A domestic servant, aged 19. Her illness began four months before admission with severe cardiac pain and breathlessness, repeated at intervals until her death. Latterly there was dropsy of the lower limbs, enlargement of the cardiac area, feeble sounds without murmur, and irregular action of the heart. In this case the valves and the coronary arteries were quite healthy, but there was thrombosis of the superior vena cava and of the left ventricle. The heart was generally enlarged, weighing 16 ounces.

(3) An iron-moulder, aged 61. In this case cardiac pain was a well-marked symptom. The coronary arteries were quite healthy, but there were thickening and calcareous infiltration of the aortic curtains and dilatation of the aortic orifice. The muscular tissue of the heart was pale and soft.

(4) A carter, aged 44. Had severe attacks of angina pectoris, with great breathlessness. The pain extended to each side of the face, passed down both arms and legs, and was accompanied by a sense of impending death. He died during an attack of extreme breathlessness. He had been ill altogether for about a year, and well-marked V.S., V.D. murmurs were present. Fibroid disease of the heart-muscle was well

marked, and the whole heart was greatly enlarged, weighing 29 ounces. There was atheroma with dilatation of the arch of the aorta. The coronary arteries were healthy.

II. CORONARY ARTERIES DISEASED—102 CASES.

In analyzing the 102 cases in which the coronary arteries were recorded to be diseased, I shall subdivide them into two groups, viz.: (a) Cases in which there was no fibroid disease (fibrous transformation) of the heart muscle; and (b) Cases in which this change was present. I think this a convenient subdivision, as presenting under one section all the cases of fibroid disease, a lesion frequently, though not so frequently as I formerly thought, associated with coronary artery disease or obstruction.

(a) *Coronary Arteries Diseased without Fibroid Disease (Fibrous Transformation) of the Heart-Wall—80 Cases.*

It is on the whole somewhat difficult to classify the 80 cases included under this heading, but from a consideration of the records both of the clinical and the anatomical details I have endeavoured to diagnose the predominating, and probably primary, malady, and to class the cases accordingly. This classification is shown in the following table:

TABLE OF PRIMARY OR PREDOMINATING DISEASES.

Disease.	Cases.
Cardiac—Fatty, 3 ; Mitral and tricuspid stenosis, 1 ;	
Aortic valve disease, 5 ; Arterio-sclerosis, 2 ;	
Dilatation and hypertrophy, 7 ; Pericardial	
adhesion, 1, - - - - -	19
Renal disease, chiefly chronic tubular or interstitial,	16
Cerebral haemorrhage, - - - - -	8
Cancer—gullet, 3 ; mamma, 1 ; stomach, 1 ; liver, 3 ;	
intestines, 1 ; ovary, 1, - - - - -	10
Pneumonia, acute lobar, - - - - -	6
Bronchitis, 3 ; bronchiectasis, 2 ; pleurisy, 1, - - -	6
Trauma, - - - - -	6

Leptomeningitis and cerebral softening,	-	-	-	-	1
Disease of urinary bladder,	-	-	-	-	2
Perinephritis,	-	-	-	-	1
Peritonitis,	-	-	-	-	2
Acute miliary tuberculosis,	-	-	-	-	1
Gall-stones,	-	-	-	-	1
Appendicitis,	-	-	-	-	1
Total,	-	-	-	-	80

(b) *Coronary Arteries Diseased with Fibroid Disease (Fibrous Transformation) of the Heart-Wall—22 Cases.*

In classifying the 22 cases under this heading we may proceed as in the tabulation of class (a), i.e. the different cases may be numbered under the predominating or primary lesion as judged both by clinical and anatomical details.

TABLE OF PRIMARY OR PREDOMINATING DISEASES.

	Disease.	Cases.
Cardiac—Myomalacia,	- - - - -	4
Thrombosis,	- - - - -	3
Aortic disease,	- - - - -	1
Renal,	- - - - -	3
Pneumonia,	- - - - -	1
Cerebral haemorrhage and thrombosis,	- - - - -	5
Cancer—stomach,	- - - - -	1
Bladder disease,	- - - - -	1
Lumbar abscess,	- - - - -	1
Hodgkin's disease,	- - - - -	1
Syphilis and cardiac,	- - - - -	1
Total,	- - - - -	22

Having thus classified, in such a manner as to show at a glance the principal pathological phenomena, the 238 cases in which notes of the actual condition of the coronary arteries of the heart have been preserved, I propose still further to analyse the records, in order to bring out certain other details which are of interest both to the clinical physician and the pathologist.

AGE.

(a) *Coronary Arteries Healthy—136 Cases.*

A statement under this heading with regard to age is perhaps hardly necessary, but it may be of interest to compare the results with those obtained in the cases of disease.

	Cases.		Cases.
Under 15 years, -	3	From 50 to 55 years, -	13
From 15 to 20 years, -	5	,, 55 to 60	, - 11
,, 20 to 25	1	,, 60 to 65	, - 20
,, 25 to 30	8	,, 65 to 70	, - 4
,, 30 to 35	7	,, 70 to 75	, - 1
,, 35 to 40	19	Unknown, -	- 14
,, 40 to 45	17		
,, 45 to 50	13	Total, -	- 136

(b) *Coronary Arteries Diseased, without Fibroid Disease (Fibrous Transformation)—80 Cases.*

	Cases.		Cases.
From 20 to 30 years, -	4	From 65 to 70 years, -	6
,, 30 to 35	1	,, 70 to 75	, - 6
,, 35 to 40	4	,, 75 to 80	, - 4
,, 40 to 45	5	,, 80 to 85	, - 1
,, 45 to 50	11	Unknown, -	- 4
,, 50 to 55	10		
,, 55 to 60	10	Total, -	- 80
,, 60 to 65	14		

From this table it is at once seen that the largest number of cases occurred between 45 and 65 years of age. Under the age of 45 there were 14, and above 65 there were 21 cases. Coronary artery disease, then, so far as these figures go, is much more commonly met with after the middle period of life.

(c) *Coronary Arteries Diseased with Fibroid Disease (Fibrous Transformation)—22 Cases.*

	Cases.		Cases.
From 35 to 40 years, -	1	From 65 to 70 years, -	5
,, 40 to 45	1	,, 70 to 75	, - 2
,, 45 to 50	2	Unknown, -	- 2
,, 50 to 55	7		
,, 55 to 60	1	Total, -	- 22
,, 60 to 65	1		

Here again it is at once seen that all the cases except two occurred after the age of 45. The table also brings out this additional point, perhaps not of great moment owing to the smallness of the numbers, that where the coronary disease is associated with fibroid disease (fibrous transformation) of the heart-wall the greatest number of cases occurred between the ages of 50 and 70.

If we take the ages of the whole 102 cases in which the coronary arteries were found to be diseased, we find that 86 of them were 45 years of age and upwards, and that only 16 were under 45.

SEX.

(a) *Coronary Arteries Healthy.*

Of the 136 cases in which, upon examination, the coronary arteries were found to be healthy, 102 were males and 34 females.

(b) *Coronary Arteries Diseased, without Fibroid Disease.*

Males,	-	-	-	-	59
Females,	-	-	-	-	21
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Total,	-	-	-	-	80

(c) *Coronary Arteries Diseased, with Fibroid Disease.*

Males,	-	-	-	-	15
Females,	-	-	-	-	7
<hr/>					
Total,	-	-	-	-	22

These figures show that of the total cases of diseased coronary arteries the lesion occurred 74 times in males and 28 times in females.

CONDITION OF THE HEART IN CORONARY ARTERY DISEASE.

Under this heading I shall attempt to show, by means of tables, the frequency with which lesions of the heart, other

than that under which the case may possibly have been classified in my general table, were associated with disease of the coronary arteries. Manifestly the point is important, as integrity of the coronary circulation must be of the greatest service in the maintenance of cardiac compensation. As before, I shall analyse first those cases in which no fibroid disease (fibrous transformation) of the heart-wall was associated with the degenerated state of the coronary arteries.

(a) *Cases without Fibroid Disease (Fibrous Transformation).*

Fatty heart,	- - - - -	was noted	16 times.
Atrophy of the heart,	- - - - -	„	5 „
Simple hypertrophy of the left ventricle,	- - - - -	„	20 „
General hypertrophy, with dilatation,	- - - - -	„	23 „
Aortic valve disease,	- - - - -	„	9 „
Aortic and mitral disease,	- - - - -	„	2 „
Thrombosis of the heart,	- - - - -	„	5 „
Brown atrophy of the heart,	- - - - -	„	4 „
Pericardial adhesion,	- - - - -	„	once.
Myomalacia cordis,	- - - - -	„	2 times.
Paleness or softness,	- - - - -	„	11 „
A healthy state of the heart,	- - - - -	„	10 „

From this tabular statement we see that valvular disease pure and simple is not very frequently associated with disease of the coronary arteries. Even the cases in which the aortic curtains were abnormal are not numerous, although disease of these curtains might readily enough extend to the coronary orifices. We see that morbid conditions directly referable to the muscular wall of the heart are of special frequency where the coronary arteries are diseased. Hypertrophy, dilatation, fatty heart, softening, thrombosis, are the conditions of the heart very likely to be associated with coronary disease, a fact not to be wondered at when we reflect upon the serious interference with the healthy nutrition of the heart-wall which must nearly always be present. The cases of simple hypertrophy of the left ventricle were all associated with chronic renal disease, and this may be taken as indicating that the cardiac coronary arteries partake in the general arterial de-

generation which so frequently accompanies chronic Bright's disease. Fatty heart is shown to be a moderately frequent accompaniment of coronary artery disease, and the following table shows the frequency of occurrence of its two forms in these 80 cases:

CASES OF FATTY HEART, ASSOCIATED WITH CORONARY
ARTERY DISEASE.

Fatty infiltration ("fatty growth on the heart"),	- - - - -	12 cases.
Fatty degeneration,	- - - - -	4 , ,
Total,	- - - - -	16 cases.

CONDITION OF THE AORTA.

The following table shows the condition of the aorta in 27 of these 80 cases, in which the coronary arteries were diseased without fibroid disease (fibrous transformation) of the heart-wall:

Atheroma,	- - - - -	23 cases.
Calcareous plates,	- - - - -	3 , ,
Dilatation,	- - - - -	1 case.
Total,	- - - - -	27 cases.

This means that in 53 of the 80 cases at present under review the aorta was healthy, and it thus follows, that disease of the coronary arteries of the heart may often be quite independent of any affection of the aorta, and cannot be regarded as a mere extension of a morbid process from this vessel.

(b) *With Fibroid Disease (Fibrous Transformation).*

Before tabulating the cardiac conditions observed under this heading, I may observe that fibroid or fibrous transformation of the heart-muscle was more or less extensively present in them all, and that in some of them the state of localized necrotic softening to which the name myomalacia cordis has been given by Ziegler was characteristically present.

I have already at considerable length, and in different communications published my views on the etiology and histology of fibroid heart, and shall at present content myself with this reference to these writings:¹

Fatty degeneration,	-	-	-	-	was noted twice.
Fatty infiltration,	-	-	-	-	,, once.
Atrophy, general,	-	-	-	-	,, once.
Atrophy, localized to apex,	-	-	-	-	,, once.
Simple hypertrophy of the left ventricle,	-	-	-	-	,, 5 times.
General hypertrophy with dilatation	-	-	-	-	,, 8 times.
Aortic valve disease,	-	-	-	-	,, twice.
Thrombosis of the heart,	-	-	-	-	,, 3 times.
Pericardial adhesion,	-	-	-	-	,, twice.
Myomalacia cordis,	-	-	-	-	,, 5 times.
Rupture of the heart,	-	-	-	-	,, once.

The foregoing table is of interest as showing that, in addition to the fibroid disease present in all, general enlargement of the heart, and simple hypertrophy of the left ventricle were frequent conditions. In five of the cases also there was myomalacia cordis which in one had led to rupture of the organ. It is likewise noticeable that here, as in the cases unaccompanied by fibrous transformation of the heart-wall, valvular disease *per se* is not a very frequent occurrence.

CONDITION OF THE AORTA.

Atheroma,	-	-	-	-	-	-	12 cases.
Calcareous plates,	-	-	-	-	-	-	2 ,
Total,	-	-	-	-	-	-	14 cases.

It is thus shown that when coronary artery disease is associated with fibrous transformation of the heart-wall it is proportionally more frequently associated with atherosomatous disease of the aorta.

¹ *Glasgow Medical Journal*, Series 5, Vol. xxii., p. 413, 1884. *The Lancet*, December 10, 17, 24, and 31, 1887. *The Journal of Pathology and Bacteriology*, Vol. II., No. 2, p. 190, 1893.

CLINICAL PHENOMENA ASSOCIATED WITH DISEASE OF THE CORONARY ARTERIES OF THE HEART.

In this part of my investigation I have made a minute study of the clinical summaries supplied to me by the physicians and surgeons at the time I made the post-mortem examinations. These summaries, some of which were full and detailed, are preserved with the pathological reports, and all of them have been carefully read and tabulated with a view to the present paper.

OCCUPATION.

The occupation was noted in 91 out of the 102 cases in which the coronary arteries were found to be diseased. Of 70 men the occupations were as follows: Labourers, 16; Carters, 4; Engineers, 4; Masons, 3; Seamen, 3; Warehousemen, 3; Brokers, 2; Publicans, 2; Joiners, 2; Shoemakers, 2; Stone-polishers, 2; Miners, 2; Quarrymen, 2; Lamplighters, 2; Potters, 2; Coachman, 1; Gatekeeper, 1; Sawmiller, 1; French-polisher, 1; Boilermaker, 1; Reedmaker, 1; Baker, 1; Colourmaker, 1; Fireman, 1; Debt-collector, 1; Railwayman, 1; Calico-printer, 1; Painter, 1; Clothlapper, 1; Merchant, 1; Cattle-driver, 1; Tramway-guard, 1; Packer, 1; Clerk, 1.

The occupations of 21 women were as follows: Housewives, 13; Mill-girls, 2; Charwomen, 2; Needle-women, 2; Weavers, 2.

From these figures no very definite conclusion can be drawn as to the influence of occupation upon the development of disease of the cardiac coronary arteries. As regards men, however, it might perhaps be fairly enough deduced from the facts before us that those engaged in hard muscular work, or exposed to vicissitudes of weather, or employed at work involving both of these conditions, are on the whole more liable.

SYMPTOMS ASSOCIATED WITH DISEASE OF THE CORONARY ARTERIES.

Any classification of the symptoms observed in our 102 cases of disease of the coronary arteries of the heart can, of

necessity, only be of the most general kind. Minute details as to pulse, respiration, etc., can, of course, not be given: but an examination of the clinical summaries may at least enable us to find out how the case was regarded from the clinical point of view, and so far will be of value.

(a) *80 Cases without Fibroid Disease.*

Cardiac and vascular symptoms predominated in	17 cases.
Renal symptoms	„ „ 15 „
Pulmonary symptoms	„ „ 12 „
Bronchitis, 5 cases.	
Pneumonia, 6 cases.	
Pleurisy, 1 case.	
Cerebral symptoms	„ „ 7 „
Symptoms of malignant disease	„ „ 10 „
Abdominal symptoms	„ „ 3 „
Surgical symptoms	„ „ 11 „
Trauma, 5 cases.	
Surgical disease, 6 cases.	
Sudden death occurred in	- - - - 5 „
Total,	- - - - <hr/> 80 cases.

The foregoing tabular statement may be taken as indicating in general terms the diagnosis arrived at during the life of the patient. In the same manner I shall indicate in tabular form the clinical aspect of the twenty-two cases in which distinct fibroid disease of the heart-wall was found to be associated with the affection of the coronary arteries.

(b) *22 Cases with Fibroid Disease.*

Cardiac and vascular symptoms predominated in	7 cases.
„ „ „ with sudden death in	2 „
Renal symptoms	„ „ 4 „
Pulmonary symptoms (pneumonia),	„ „ 1 case.
Cerebral symptoms	„ „ 5 cases.
Surgical symptoms	„ „ 2 „
Symptoms of malignant disease	„ „ 1 case.
Total,	- - - - <hr/> 22 cases.

The only general conclusion that can be drawn from this tabular statement of predominating symptomatology is that coronary artery disease may be an element to be reckoned with in a large variety of clinical conditions. The figures show, however, that a morbid state of the coronary arteries is most likely to be met with in cases primarily of cardiac or of renal disease. Under the last heading also may be included cases of cerebral haemorrhage, which frequently have their starting-point in renal disorder. The frequency with which disease of the cardiac coronary arteries was met with in patients dying from malignant tumours is also a striking phenomenon, and is in keeping with my experience that in post-mortem examinations of cancerous disease I very often found a wide-spread and often very advanced arterio-sclerosis. These observations seem to me to prove that atheroma of the arteries of the heart may often exist without symptoms directly pointing to the arterial lesion *per se*, so long as a fair general health is maintained. The moment, however, a severe injury, an acute illness, or the development of a malignant tumour takes place, the enfeebled state of the heart induced by the slowly progressive coronary disease makes itself obvious, and may soon give rise to the most alarming signs of cardiac failure.

CARDIAC MURMURS IN CORONARY ARTERY DISEASE.

(a) *In 80 cases without Fibroid Disease.*

Murmurs of various kinds were recorded as having been present in 16 of the clinical summaries; in 9 of the summaries they were definitely stated to have been absent. We have thus 25 cases in all in which information as to murmurs can be analysed. A ventricular-systolic murmur was noted in 15 cases: in 10 it was limited to the apex region, and in 2 to the basal region; in 2 it was heard over the whole cardiac area; and in 1 it was confined to the tricuspid area. A ventricular-diastolic murmur was only recorded three times; and an auricular-systolic murmur was not noted in any of the summaries. Among the 9 cases in which murmurs were

definitely stated to be absent, 6 presented unequivocal cardiac lesions on post-mortem inspection. Two of these suffered from angina pectoris, and in one death took place suddenly. In 2 of these cases reduplication of the second sound was noted: in 4, tachycardia; in 2, irregular cardiac action; and in 2, muffled sounds.

On further analysing the cases in which murmurs were noted I find that in 9 there was no structural affection of the valves; that in 5 the aortic curtains were diseased; and in 2 the mitral curtains were affected. In one of the two mitral cases the tricuspid was also diseased.

Of the 9 cases in which murmurs were absent only 1 presented a valvular lesion situated in the aortic curtains.

(b) *In 22 cases with Fibroid Disease.*

Murmurs were recorded to have been present in 7, and to have been absent in 2 of the cases. A systolic murmur was noted five times; a combined systolic and diastolic murmur once; and a simple diastolic murmur once. Of the seven cases in which murmurs were noted 4 presented no valvular disease, and 3 did, all of the aortic curtains. In one, however, there was a much dilated aorta, and in one a recent pericarditis. In the two cases without murmur there was no valvular disease.

We have thus in our 102 cases of coronary artery disease 34 in which information as to cardiac murmurs has been preserved. In 11 of these there was no murmur, and in only one of these was there a structural lesion of the valves. In 23 cases murmurs were noted, and of these 10 presented structural disease of the valves, and in 13 the valves were found to be free from structural change.

The numbers are too small to permit of any definite conclusions of a general kind as to the relationships of cardiac murmurs to disease of the coronary arteries. So far as they go, however, they teach us that disease of these vessels may exist without the presence of murmurs; and that where murmurs are present they are not due to organic valve disease in at least half of the cases examined. Under such circumstances

the murmur must owe its origin to these changes in the heart-wall, in the production of which the disease of the coronary arteries must often play an important, if not the only, part.

In the somewhat exhaustive tabulation of the 102 cases of disease of the coronary arteries which was necessary for the purposes of this paper, information as to the duration of the last illness and the mode of death was noted. On scrutinizing the information contained in this portion of the tables I have come to the conclusion that, as regards the arterial disease, a statement of the duration of symptoms is of no special value, as, in many cases of coronary artery disease, there must often be long periods during which no symptoms are complained of. As to the mode of death also, except in those cases to be considered immediately, where the death with fair probability might be attributed chiefly to the morbid state of the arteries, the information is not of special significance for our present enquiry. There are, however, in an enquiry such as this, two matters which do require special attention and investigation, these are the occurrence of sudden death and of angina pectoris in association with disease of the coronary arteries of the heart.

SUDDEN DEATH.

In the 102 cases of disease of the coronary arteries sudden death was noted to have taken place 7 times; in the 136 cases where the arteries were healthy it occurred once: 8 times in all. The importance of sudden death in connection with a diseased condition of the coronary arteries of the heart justifies a somewhat detailed summary of the cases in which it took place.

(a) *Sudden Death with healthy Coronary Arteries.*

A carter, aged 42. This case has already been given in detail as Case 4 of the series of examples of angina pectoris without arterial disease, recorded at the beginning of this paper.

(b) *Sudden Death with diseased Coronary Arteries, but without Fibroid Disease (Fibrous Transformation).*

(1) A housewife, aged 65. The patient was admitted to one of the surgical wards, suffering from dislocation of the hip, after reduction of which she had shown no symptoms of ill-health. She was found dead in her bed about two hours after she had taken her dinner, at which time she had apparently been in good health. The heart was fatty; there were patches of atheroma in the right coronary artery; and the aortic curtains were atheromatous. There was a patch of myomalacia cordis (acute necrotic softening) in the septal region. The brain presented healthy appearances. The death was obviously due to sudden cardiac failure, and the association of coronary disease with acute softening cannot be overlooked in endeavouring to ascertain the immediate cause of the fatal issue.

(2) A seaman, aged 65. He had been suffering from dyspnoea for sixteen months, and from cough for twelve weeks before admission. He had albuminuria and dropsy. The pulse was 94, and thready. There was evidence of great enlargement of the heart, with apex and sternal V.S. murmurs. He died suddenly after getting out of bed and walking into a side-room. The post-mortem examination revealed interstitial nephritis; great dilatation and hypertrophy of the heart; and extensive disease of the left coronary artery, which was surrounded by a calcareous ring just where it divides into the transverse and descending branches.

(3) A labourer, aged 56. He had suffered from winter cough for four winters, from dyspnoea for five weeks, and from oedema for eight days before admission, after which these symptoms were improving, when he died suddenly. During life there was physical evidence of great enlargement of the heart, but no murmur. On post-mortem examination the heart was found to be enormously enlarged, weighing twenty-nine ounces. The valvular structures were healthy and competent. There was much atheroma of the coronary arteries, with narrowing of the lumen of the right. The aorta was not markedly atheromatous. There was passive hyperaemia of the liver, spleen, and kidneys.

(4) A woman, aged 68, was admitted with fracture of the femur. Although the death was sudden, and the coronary arteries were found to be much diseased, her death was rather to be attributed to an acute, though latent, lobar pneumonia.

(5) A stone-cutter, aged 45. He had been ill for two years with cough and dyspnoea. Latterly there was much oedema, with cyanosis and albuminuria. Death occurred suddenly from cardiac failure. The heart was found to be hypertrophied and dilated, but the valves were normal and competent. There was much atheroma and calcification of the coronary arteries. Silicosis of the lungs was also present.

(c) *Sudden Death with diseased Coronary Arteries and Fibroid Disease (Fibrous Transformation).*

(1) A merchant, aged 45. There was a clinical history of frequent attacks of angina pectoris two years before death, with good health in the interval. Death took place with startling suddenness during the excitement induced by his place of business taking fire. The coronary arteries were found to be narrowed, and there was extensive fibroid disease of the wall of the left ventricle, with considerable fatty infiltration of the external surface of the right ventricle.

(2) A commission agent, aged 51. He had suffered from shortness of breath and palpitation for about three years, and death occurred suddenly during sleep. The cardiac sounds had been noted to be pure, but there was evidence of dilatation of the right side of the heart. At the post-mortem examination atheroma and occlusion of the coronary arteries were discovered, with fibroid disease and recent haemorrhagic myomalacia cordis. Cardiac thrombosis was also present, and the heart weighed $24\frac{1}{2}$ ounces. In this case there can be little doubt that the sudden death was solely due to the effects upon the heart-wall of the coronary artery disease.

From experimental pathology we know that sudden complete occlusion of a large branch of the coronary arteries stops the heart's action in one or two minutes at the most. The cases which have just been summarized seem to me to prove that disease of these arteries is a very powerful predisposing and

occasionally an exciting cause of sudden death. In 136 cases in which the arteries were healthy and in 75 of which the heart was otherwise seriously diseased sudden death is recorded to have taken place only once. In 102 cases where the cardiac arteries were the seat of disease death took place suddenly in seven. In not one of these cases can the influence of the diseased coronary arteries be excluded in estimating the probable cause of the sudden termination, not even in that one in which acute eruptive pneumonia was found. In cases (b) No. 1 and (c) Nos. 1 and 2, we may with very fair probability regard the atheromatous condition of the coronary arteries as the ultimate anatomical basis of the finally sudden demise.

CARDIAC PAIN AND ANGINA PECTORIS.

Four cases in which anginous symptoms without disease of the coronary arteries were observed have already been recorded in the opening section of this paper. To these there fall to be added 15 cases in which the coronary arteries were found, on inspection, to be diseased, making a total of 19 cases in the whole series of 238 in which angina pectoris or cardiac pain, more or less severe, was present. The very general belief that an important relationship exists between the development of angina pectoris and the existence of disease in the coronary arteries renders a somewhat careful scrutiny of these cases necessary; and I shall briefly summarize the fifteen, dividing them into two classes, according as fibrous transformation of the heart-wall was absent or present:

(a) *Without Fibroid Disease (Fibrous Transformation).*

(1) An engineman, aged 34. In this case chest pain, with tachycardia, irregularity of the cardiac action, and feeble sounds but no murmur, were prominent symptoms. The patient was very stout, and had no albuminuria. The heart was the seat of fatty metamorphosis of both varieties, and was generally dilated. The wall of the left ventricle was thin, and the coronary arteries were atherosomatous, though not extremely so.

This was clearly a case in which the primary disease was of the cardiac muscle, and in the production of this the diseased coronary arteries doubtless played a part.

(2) A stone-cutter, aged 64. Suffered from cardiac pain (angina pectoris), palpitation, dyspnoea, and fainting fits. The symptoms had been present for a year. The heart was generally dilated and hypertrophied, and weighed $21\frac{1}{2}$ ounces. The valves were normal and competent, and, beyond passive hyperaemia, there was no lesion of the viscera. There was moderate atheroma of the coronary arteries and of the aorta. Here also the disease was manifestly cardiac throughout.

(3) A quarryman, aged 54. The symptoms were of five months' duration in all. He had had one or two severe anginous attacks. The other symptoms were dyspnoea, weakness, dependent oedema, and signs of aortic obstruction and regurgitation. There was great hypertrophy of the left ventricle and slight atheroma of the coronary arteries. The cardiac condition was clearly secondary to interstitial nephritis.

(4) A reed-maker, aged 48. Symptoms of chronic bronchitis, with persistent pain between the shoulders. There was slight atheroma of the coronary arteries, with hypertrophy of the left ventricle, secondary to interstitial nephritis.

(5) A lamplighter, aged 39. While in hospital he had repeated daily unmistakable attacks of angina pectoris, in one of which he died. He had suffered from attacks of angina for eleven months before his admission. On inspection, there was found almost complete obstruction of the orifice of the left coronary artery by the encroachment upon it of a thickened patch of atheroma extending from the aorta. There was also a limited pericardial adhesion over the surface of the right ventricle, and brown atrophy of the muscle fibre. With the exception of a slight interstitial nephritis the other organs were healthy. This was very clearly a case of angina pectoris, due to the left coronary artery being obstructed.

(6) An engineer, aged 48. Had suffered from anginal pain for four months, with evidence of chronic renal disease as well. The coronary arteries were atheromatous and tortuous, but the heart was not enlarged, and the valves were normal. There was chronic interstitial nephritis.

(7) A labourer, aged 35. Had suffered from cardiac pain, extending into the upper part of the chest, for eight weeks. There was general dilatation of the heart, which weighed 22 ounces. The descending branch of the left coronary artery was atheromatous. The valves were normal in structure, and, beyond passive hyperaemia of the viscera, no other lesion was discovered. The case was clearly cardiac throughout.

(8) A labourer, aged 46. He had suffered from cardiac pain, lividity, and dyspnoea, for nine weeks, the symptoms being regarded as those of chronic bronchitis. The heart was generally dilated, weighing 17 ounces. The valves were normal in structure, and the orifices only moderately dilated. The left coronary artery was markedly atheromatous. In this case the cardiac lesion was practically the only primary one.

(9) A tailoress, aged 24. The case was one of very characteristic angina pectoris, paroxysmal pain beginning under the left nipple and shooting into the left shoulder and arm, the attacks being associated with paroxysms of dyspnoea. The duration of the symptoms was unknown, and the signs were those of aortic obstruction and regurgitation. Post-mortem examination revealed aortic valve disease, obstruction of the orifice of the right coronary artery, and extensive atheroma of the aorta.

(10) A housewife, aged 46. Rheumatic fever at the age of 19. She suffered from cardiac pain and palpitation for a month before admission. On inspection there was found stenosis of the mitral and tricuspid orifices, with atheroma of the left coronary artery.

(b) With Fibroid Disease (Fibrous Transformation).

(1) A clothlapper, aged 66. He had suffered from much precordial pain, with symptoms of Bright's disease, for about three months. The post-mortem examination revealed calcified coronary arteries, with obstructed lumen, especially of the left, and extensive fibroid disease in the areas of distribution of the obstructed vessels. There was also a slight recent adhesive pericarditis, which was not regarded as sufficient to have accounted for all the pain.

(2) This case has already been summarized as (c) No. 1 under the heading of Sudden Death.

(3) A tramway guard, aged 44. Characteristic angina pectoris, beginning in the abdomen, extending to the chest and down the left arm. Attacks of pain had been present for about a year before death. On inspection, cardiae thrombosis, dilated heart, fibrous change in the wall of the left ventricle, and atheroma of the coronary arteries, especially of the left, were found to be present.

(4) A housewife, aged 54. Attacks of pain, beginning in the fingers of the left hand, passing up the arm, and terminating in the pectoral region. She had suffered from these attacks for six weeks, but they had only become very severe about ten days before admission. There was a V.S. murmur at the apex, which was displaced downwards and to the left. The autopsy revealed myocardial oedema, rupture of the left ventricle, many patches of fibrous transformation, and extensive atheroma and calcification of the coronary arteries, with similar changes in the thoracic aorta, the aortic curtains being competent.

(5) A labourer, aged 50. The symptoms were definitely cardiac. He had attacks of pain, beginning at the heart and passing round to the back. Bronchitis had been troublesome for three years, and oedema had set in three months before admission. Both coronary arteries were calcified and narrowed near their origins. There was great dilatation of the heart, with aortic valve disease. Fibrous transformation was well marked near the apex, the wall of the heart in this region being considerably diminished in thickness.

That angina pectoris may frequently occur in patients who have no atherosomatous or calcareous disease of their coronary arteries has long been well known, and is abundantly proved by the first four of the 19 summaries given in this paper. It is worthy of note, however, that in two of these four cases fibrous transformation of the heart-wall was present in spite of the healthy condition of the coronary arteries. In one of these two I was of opinion that the fibrous change was of embolic origin, so that here we might have had a disturbance of the intrinsic circulation of the heart without any actual primary disease of the arterial wall. My experience would

lead me to believe that embolism of the coronary arteries as well as atheromatous disease may sometimes be the starting-point of attacks of angina pectoris. From these considerations then it may be concluded that any serious interference, especially if suddenly induced, with the histological integrity of the cardiac fibre is a very frequent cause of angina pectoris.

Turning now to the 15 cases in which the arteries were found to be diseased, I have to point out that in 9 of them typical angina pectoris may be admitted to have been present. In these nine cases the terms "angina pectoris," "angina," "anginal pain," "anginous seizures" were actually used in the clinical reports. The remaining 6 were simply described as having suffered from "cardiac pain," but it may also be allowed in two or three of these, from the description given that the pain was of anginal character. We may say then that angina pectoris was present in from 10 to 15 per cent. of the 102 cases of disease of the cardiac arteries analysed in this paper. This percentage is perhaps not so great as one would have expected from the ordinary teaching on this subject, but it is large enough to prove that atheroma of the coronary arteries is a very important factor in the causation of this distressing symptom of heart disease. It is also evident that in cases with fibrous transformation of the heart-wall angina pectoris is relatively a more frequent symptom than in cases where this change is not present. Associated with fibrous change, the symptom occurred about once in every 4 cases, without fibrous change about once in every 8 cases, in round numbers.

CONCLUSIONS.

From the analysis of the 238 cases dealt with in this paper I may draw the following general conclusions:

(1) Although in many cases, especially of chronic cardiac or renal disease, we may, on careful consideration of all the phenomena, have good grounds for suspecting the presence of atheromatous disease of the coronary arteries, there are no signs or symptoms which can be looked upon as positive or pathognomonic.

(2) Disease of the cardiac coronary arteries is much more commonly met with as one of many co-existent morbid conditions than as an affection *per se*.

(3) On the whole coronary artery disease is not common as an accompaniment or complication of ordinary valvular disease of the heart, and it is more frequently associated with aortic than with mitral valve disease.

(4) The conditions of the heart most frequently associated with or resulting from coronary artery disease are hypertrophy and dilatation, fibrous transformation of the muscular fibre, fatty metamorphosis, acute necrotic softening, localized atrophy of the heart-wall, and thrombosis.

(5) The frequency of the existence in the same case of coronary artery disease and chronic renal disease, seems to indicate that the coronary arteries of the heart participate largely in the tendency to generalized arterial degeneration so commonly met with in chronic Bright's disease.

(6) Atheroma of the coronary arteries, and of the thoracic aorta often co-exist in the same case, but the coronary arteries are frequently found to be extensively diseased when the aorta appears to be quite healthy.

(7) Disease of the coronary arteries of the heart is a frequent factor in the causation of sudden death and of angina pectoris, but on the other hand serious disease of the cardiac arteries is often found to be present post-mortem in cases in which during life no complaint of angina pectoris or cardiac pain had ever been made.

(8) In cases of cardiac pain or angina pectoris associated with disease of the coronary arteries, in which only one of the two arteries is involved, or in which the lesion is more marked in one vessel than in the other, the left coronary is that most frequently affected.

In the laborious work of tabulation for the purposes of this paper I take this opportunity of gratefully acknowledging the valuable assistance I have received from my successive house physicians in the Glasgow Royal Infirmary, Dr. Archibald Young, Dr. William Burns, and Dr. William Martin.



